United States
Department of
Agriculture

Forest
Service

North Central
Forest Experiment
Station

Research Paper
NC-322

Performance of a Logging Truck with a Central Tire Inflation System

John A. Sturos, Douglas B. Brumm, and Andrew Lehto

The policy of the United States Department of Agriculture Forest Service prohibits discrimination on the basis of race, color, national origin, age, religion, sex, or disability, familial status, or political affiliation. Persons believing they have been discriminated against in any Forest Service related activity should write to: Chief, Forest Service, USDA, P.O. Box 96090, Washington, DC 20090-6090.

Our job at the North Central Forest Experiment Station is discovering and creating new knowledge and technology in the field of natural resources and conveying this information to the people who can use it. As a new generation of forests emerges in our region, managers are confronted with two unique challenges: (1) Dealing with the great diversity in composition, quality, and ownership of the forests, and (2) Reconciling the conflicting demands of the people who use them. Helping the forest manager meet these challenges while protecting the environment is what research at North Central is all about.

North Central Forest Experiment Station
Forest Service—U.S. Department of Agriculture
1992 Folwell Avenue
St. Paul, Minnesota 55108
Manuscript approved for publication February 28, 1995
1995

Printed on recycled recyclable paper

Performance Of A Logging Truck With A Central Tire Inflation System

John A. Sturos, Douglas B. Brumm, and Andrew Lehto

INTRODUCTION

Each year the USDA Forest Service, other government agencies, and private forest products companies construct many miles of new logging roads. Many of these roads are low-volume and low-standard roads. The National Forest System spends about $250 million each year on road and bridge construction and reconstruction. Because constructing logging roads is expensive, it is important to know as much as possible about the performance of log trucks and their tires on these roads so that adequate roads can be designed and built at minimum expense.

Therefore, the Forest Service has undertaken a research/demonstration program to look at the effects of tire inflation pressure on log-truck performance and forest roads and the implications these effects may have on timber hauling and road maintenance and construction costs (Gililland and Ryburn [1987], Ad Hoc Central Tire Inflation Applications Team 1988). The program focuses on using central tire inflation (CTI) technology to control tire pressures. Recent military developments in radial tire designs and CTI systems allow a driver to automatically and uniformly vary the inflation pressure of a truck's tires while the truck is moving.

John A. Sturos, Research Mechanical Engineer, North Central Forest Experiment Station, Houghton, Michigan.

Douglas B. Brumm, Associate Professor, Electrical Engineering Department, Michigan Technological University, Houghton, Michigan.

Andrew Lehto, Civil Engineer, USDA Forest Service, Hiawatha National Forest, Rapid River, Michigan.

The requirements differ for acceptable off-road trucks and highway trucks. A CTI system may be a useful device to resolve this conflict by conforming tire inflation pressure to the type of road surface and operating conditions. With a CTI system, a truck's tire pressure can be lowered on an unpaved road and then automatically raised to a higher highway pressure when the truck moves onto a paved road. The pressure is varied to obtain the appropriate tire deflection for the tires as operations change from an empty to a loaded truck, from high to low speed, and good to poor traction. Tire deflection is the key to understanding the use of CTI technology. Tire deflection is defined as the change in tire section height from the freestanding height to the loaded height. The percent deflection is the ratio of that change to the freestanding section height (X 100). At the lower inflation pressures (increased tire deflections), the tire's imprint or contact area is greatly increased, and the load is applied over a substantially larger area. Preliminary proof-of-concept tests indicate that larger tire imprints may result in lower costs for forest road construction, surfacing, and maintenance. These larger tire imprints will also dampen and greatly reduce drive-train shocks, decrease truck operational and maintenance costs, and increase driver comfort and tire life.

The objective of this research/demonstration test was to install a CTI system on an 11-axle logging truck and evaluate it on an actual timber sale for impact on the road, truck, and driver. In addition, specific structured tests were conducted to measure drawbar pull and rolling resistance.

BACKGROUND

The Forest Service has investigated central tire inflation systems in a number of states. The largest and most intensive test was conducted at

the Nevada Automotive Test Center (NATC)[1] in Carson City, under a contract with Hodges Transportation, Inc. (Hodges *et al.* 1987). Two 18-wheel logging trucks, one with high tire pressure and the other with low tire pressure, were compared, both loaded and unloaded, on identical and parallel lanes of a closed loop test course. The test course included paved highways; unpaved, washboarded secondary roads; and logging trails with potholes and moderate to severe rock sections. The results of the test included the following: (1) truck maintenance and repair costs were 8 times higher for the truck with high tire pressure; (2) components on the high-pressure truck were impacted 2 to 10 times more than those on the low-pressure truck, as measured by accelerometers; (3) the lowered tire pressure truck showed 15 percent less tire wear; (4) the high-pressure truck caused more loss of gravel on the gravel-surfaced curves; (5) washboarding was eliminated by the low-pressure truck, but it was increased by the high-pressure truck; and (6) ride comfort was greatly improved with lower tire pressures.

Several operational field tests have been conducted. The first field test to use lowered tire pressure for timber hauling was on the Moores Creek Timber Sale on the Boise National Forest (Taylor 1987). Four 18-wheel logging trucks hauled 1.7 MMBF of timber over 11 miles of unpaved roads. High (90 psi) and low (21-percent deflection) tire pressures were compared. Tire pressures were adjusted manually using an airing station and automatic deflator valves. Test results included the following: (1) road maintenance was reduced using lower tire pressures (3- to 4-inch ruts compared to 16-inch ruts); (2) lower tire pressure permitted several days of hauling that would not have been possible with high-pressure tires; (3) truck ride and operator comfort improved with lowered pressure; and (4) no tire failure occurred with lowered pressure.

The first field test to use lowered tire pressure on a road surface replacement job was on the Olympic National Forest (Taylor 1988). Six 10-yard dump trucks hauling rock were operated with lowered tire pressures over a 10-mile aggregate-surfaced haul route. One truck was equipped with a CTI system, and the tire pressures on the other five trucks were adjusted manually with an airing station and deflator valves. Test results included the following: (1) lowered tire pressure reduced the number of flat tires from an average of five to seven per week with high-pressure tires to no flats in a 10-week operation; (2) lowered tire pressure required no road maintenance in 3 weeks of haul compared to normal maintenance every 2 to 3 days during a rock haul with high-pressure tires; and (3) no washboarding occurred with lowered tire pressure.

The Forestry Sciences Laboratory, Southern Forest Experiment Station, at Auburn, Alabama, conducted a study with two 10-wheel logging trucks fitted with CTI systems (Ashmore and Sirois 1987). A 3-mile section of a good-quality, unsurfaced, sandy forest road was divided into three 1-mile test sections. The first, second, and third sections were restricted respectively to 100 psi (10-percent deflection), 65 psi (20-percent deflection), and 30 psi (30-percent deflection). The trucks made 268 passes loaded and 90 passes unloaded. The 100-psi road section failed and became impassable by the end of the testing. The 65-psi and 30-psi sections showed very little road wear and were in as good condition when the tests ended as when they started. When the trucks got stuck in the high-pressure turnaround, the operator lowered the tire pressure to 45 psi and pulled away without slipping. The 30-psi truck operated in higher gear (two-gear difference) compared to the 100-psi truck pulling through a road section near failure. The lower tire pressure truck was used to "heal" the rutted high-pressure section. In a drawbar pull test, the 65-psi truck gave a 34-percent increase on a sandy road and a 17-percent increase on a clay road, compared to the 100-psi truck. There was no significant difference between the 65-psi and 30-psi trucks.

As part of the National Central Tire Inflation Program, the Hiawatha National Forest and the Forestry Sciences Laboratory, North Central Forest Experiment Station, Houghton, Michigan, conducted a research/demonstration field test.

---

[1]*The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. It does not constitute an official endorsement or approval of any product or service by the United States Department of Agriculture to the exclusion of others that may be suitable.*

It took place on the Manistique Ranger District as part of the Carr Creek Administrative Timber Sale. An 11-axle, 77-ton (gross vehicle weight) logging truck owned by the timber purchaser was equipped with an automated CTI system for this test (fig. 1). The CTI system was designed and installed for the timber purchaser by the Nevada Automotive Test Center.

OBJECTIVES AND SCOPE

Our objectives for this research/demonstration field test were to:

1. Obtain a functional, automated CTI system for testing on an 11-axle logging truck.

2. Determine hauling effects of the CTI-equipped, 11-axle logging truck on Forest Service roads.

3. Evaluate the validity of the assumption that less road gravel is needed for log hauling using CTI.

4. Evaluate effects of CTI on truck maintenance and mobility and driver control and comfort.

5. Demonstrate traction effectiveness of lowered tire inflation pressures under varied seasonal conditions.

The scope of this study included the unstructured evaluation of the CTI-equipped truck on the Carr Creek Timber Sale plus two special tests on drawbar pull and rolling resistance.

CTI SYSTEM DESCRIPTION

The central tire inflation system was designed and fabricated by the Nevada Automotive Test Center. Compressed air was supplied by the air brake compressor. The air was filtered and dried to remove water and other contaminants and was stored in the air brake reservoir. Control valves allowed air to be supplied or removed from one of three circuits that made up the total system: one circuit for the truck front axle, the second circuit for the two drive axles and one airlift axle on the

Figure 1.—*The 11-axle Kenworth truck-trailer combination used in the study.*

truck, and the third circuit for the five axles on the trailer. Rotary valves with air-tight seals transferred air to the rotating tire/rim assemblies. Each tire/rim assembly had a manual shutoff valve to separate each tire from the system when necessary. The system controller, mounted in the cab, provided the operator with inflation/deflation controls and feedback from the total system. The controller monitored the air pressure in the tires and reservoir and controlled the inflation/deflation of the tires by opening and closing the control valves.

The tire pressures used in the study are listed in table 1. Using the front axle as an example, the truck driver used the following procedure to change the tire pressures. While on the paved highway, the tires on the front axle were set at 125 psi. Just before reaching the woods (unpaved gravel) road, the truck driver activated the CTI system with a switch, deflating the tires to the woods road, unloaded setting of 75 psi. Upon reaching the landing of the logging operation, the truck driver activated the system again, inflating the tires to the woods road, loaded setting of 115 psi. The tires on the two drive axles and trailer axles were adjusted the same way.

TIMBER SALE ROAD LAYOUT

A major objective of the national CTI program is to decrease road construction and maintenance costs by using CTI-equipped logging trucks. A research/demonstration test was conducted on the Manistique Ranger District, Hiawatha National Forest, as part of the Carr Creek Administrative Timber Sale. All timber on the sale was handled with a CTI-equipped truck.

Actual costs incurred in building roads suitable for a CTI-equipped truck were 62 percent lower than predicted costs of a conventional road on the Carr Creek Timber Sale. The primary reason for the road cost savings was the reduction in gravel costs. Gravel was used only on the first 0.25 mi of Forest Road (FR) 2217C and the first 0.1 mile on FR 2217CA, and where it was used, the depth was reduced by 33 percent. On the remaining portions of those roads and the other roads on the timber sale, only the duff and stumps were removed, thereby making use of the native topsoil over the sand subgrade.

A short section of an experimental chunkwood road was constructed to provide access over a wet area to a portion of the timber sale (Arola and Sturos 1990). Chunkwood roads have been investigated not only for crossing wet areas but also for increasing stability and structure in "sugar sand" holes in a low-cost way (Arola *et al.* 1991a). Chunkwood was produced on site with an experimental chunking machine (Arola *et al.* 1991b) using low-value and noncommercial trees. After pushing the chunkwood into the wet area (about 2 to 3 feet deep), 2 inches of pit-run gravel were spread on top of the chunkwood. Initial research on chunkwood roads has demonstrated chunkwood's viability as an alternative roadbuilding material. Chunkwood's three principal advantages are: it weighs only one-fifth of gravel, it can be used in areas where gravel is limited, and it allows good cross drainage because of its high permeability. Using chunkwood to stabilize the wet-area crossing proved to be a good choice.

Table 1.—*Tire pressure settings - CTI truck*

Road and load conditions	Front axle	Two drive axles	All trailer axles
		psi	
Highway, loaded and unloaded	125	100	100
Woods road, loaded	115	80	50
Woods road, unloaded	75	75	40

RESULTS

Carr Creek Timber Sale Evaluation

In this research/demonstration test, we found that reduced tire inflation pressures on the 11-axle logging truck:

1. Reduced damages to roads.
2. Improved the ride of the truck.
3. Improved pulling effectiveness of the six-axle tractor on snow, ice, and loose sand.
4. Reduced rolling resistance of the five-axle trailer through loose sand.
5. Substantiated that less gravel surfacing is needed to stabilize sand roads where reduced tire inflation pressures are used on logging trucks.
6. Substantiated that additional design and development for cold weather operations are needed to improve air filtering and drying, and to resolve air control system freeze-up problems. This problem may be most critical in the northern Great Lakes area of the Midwest, where low temperatures and high humidity conditions are common. This problem could be unique to the specific CTI system design that was used in this study.

Both the timber purchaser and truck driver strongly supported the CTI concept throughout the study. They believe the traction of the logging truck significantly increased on snow and ice with the CTI system. They noted improved braking on snow and ice, particularly with the trailer. The CTI system also permitted improved steering with the front axle while braking with the trailer. This gave a somewhat "pulling back" effect. Soft tires smoothed road roughness and rarely caused potholes. Even though the specified Forest Service logging roads had less gravel than normal, no problems were encountered with the soft tires. The chunkwood road section over a wet area performed very adequately and eliminated the need for a culvert. There was no damming of the drainage across the chunkwood road.

According to the truck driver, the "sugar sand" holes were consistently a problem with hard tires; there were no problems with soft tires. Hard tires always required at least one gear level lower than soft tires to successfully drive through the worst "sugar sand" holes. Eventually the holes became impassable with hard tires. By deflating the tires, the truck was able to get through the holes. The CTI system permitted the operator to inflate a flat tire while the truck was loaded and keep it inflated until he delivered the load to the mill and returned to the garage.

Structured Tests

In addition to the unstructured evaluation of the CTI-equipped truck, two structured tests were conducted—drawbar pull and rolling resistance. The data acquisition system that was used is self-contained, battery-operated, portable, and programmable (Appendix).

Drawbar pull tests were conducted on snow and ice with hard and soft tires. With an unloaded truck, drawbar pull increased 31 percent on freshly packed snow and 37 percent on icy roads, using lower tire inflation pressures (table 2). With the truck loaded, traction increased 6 percent on icy roads with soft tires, but there was no difference on freshly packed snow.

Table 2.—*Results of winter drawbar pull tests*

	Average drawbar pull (pound)			
	Truck empty		Truck loaded	
Tire pressure	Freshly packed snow	Icy road	Freshly packed snow	Icy road
Soft tires (50 psi)	9,580	4,709	16,000	6,427
Hard tires (100 psi)	7,300	3,433	16,080	6,062
Percent increase with soft tires	31.2	37.2	-	6.0

Loose sand roadways are a common problem on the Hiawatha National Forest. Typical characteristics of this so-called "sugar sand" are described as follows:

Rubicon soil type Sieve size	CBR[2] = 20 % Passing
#10	100
#40	98
#80	7
#200	0.5

The average load that was measured in the trailer pull (rolling resistance) tests on a "sugar sand" roadway was reduced 45 percent when lowered tire inflation pressures were used (figs. 2 and 3). The peak value was reduced 39 percent from 3,100 pounds to 2,200 pounds.

[2] *California bearing ratio.*

SUMMARY

The Forest Service has been investigating the application of central tire inflation (CTI) technology to log truck performance and forest roads. The results presented in this paper are part of a national research/demonstration program.

The results from this research/demonstration test with an 11-axle logging truck on the Hiawatha National Forest compare favorably with previous tests at other locations across the country. One conclusion is that lower tire inflation pressures reduce damage to forest roads and improve the ride of the truck. The test also showed that, where CTI is used, less gravel surfacing is needed to stabilize sand roads. A 62-percent reduction in road costs was realized in this study. The CTI system also provided improved traction on snow, ice, and loose sand, and reduced the rolling resistance of the five-axle trailer through loose sand. Both the timber purchaser and truck driver supported the CTI concept even though some freeze-up problems

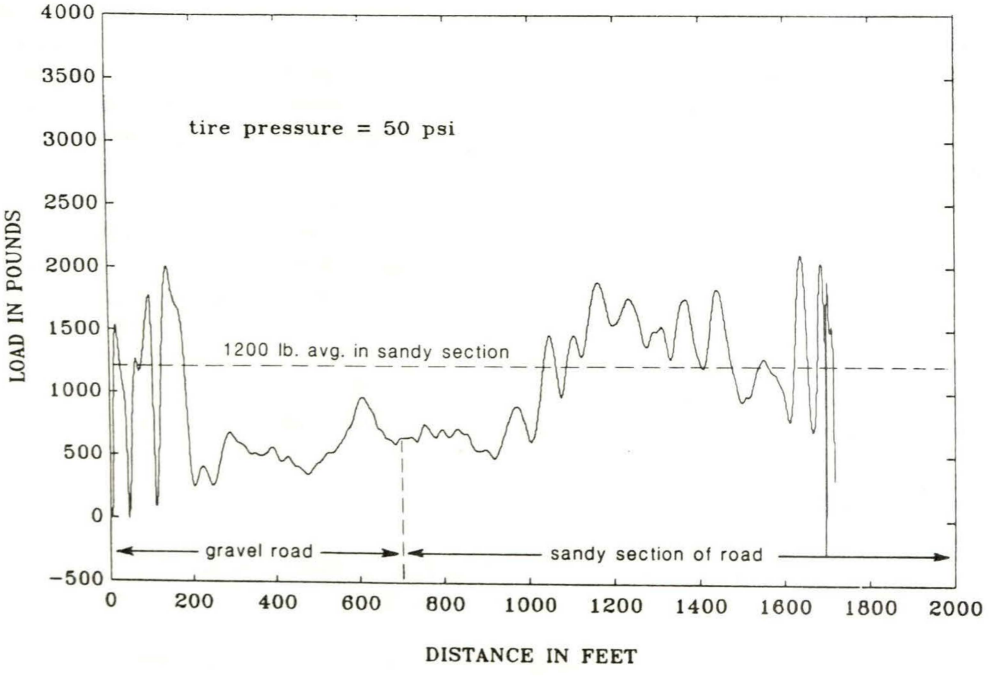

Figure 2.—*Dynamic load measured in the trailer pull (rolling resistance) test on a "sugar sand" roadway with trailer tire pressure set at 50 psi. The moisture content of the "sugar sand" was 6 percent.*

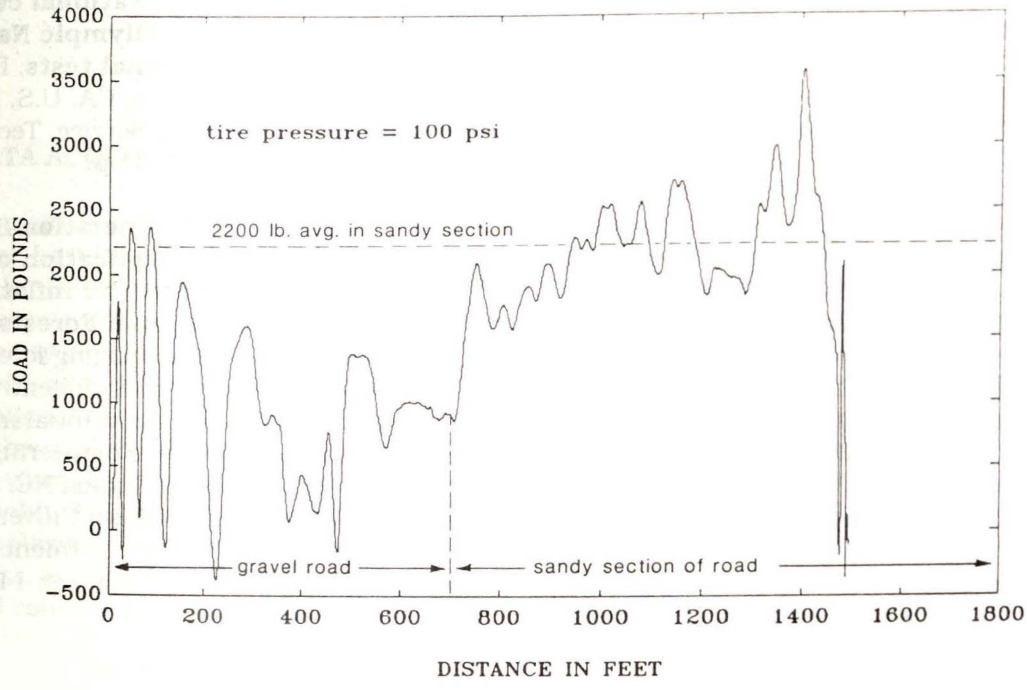

Figure 3.—*Dynamic load measured in the trailer pull (rolling resistance) test on a "sugar sand" roadway with trailer tire pressure set at 100 psi. The moisture content of the "sugar sand" was 6 percent.*

occurred in the air control system. The authors believe that the freeze-up problems were unique to the one-of-a-kind CTI system used only in this study.

Most of the Forest Service demonstrations have used trucks with external systems and/or airing stations. The hardware for these systems is available from a number of manufacturers, and each system must be custom designed and adapted for each truck as was the case in this study. To obtain more widespread acceptance of the internal CTI concept, the Forest Service has contracted with the Eaton Corporation for 15 internal CTI systems (Zealley 1990). These systems will be installed both on Forest Service trucks and on those of cooperating loggers.

LITERATURE CITED

Ad Hoc Central Tire Inflation Applications Team. 1988. **'Operation Bigfoot' technology application plan**. [San Dimas, CA]: U.S. Department of Agriculture, Forest Service, [Technology and Development Center]. 52 p.

Arola, Rodger A.; Sturos, John A. 1990. **A roadbuilding alternative for swamp crossings**. In: Managing forestry operations in a changing environment: 1990 Proceedings of the 13th annual meeting of the Council on Forest Engineering; 1990 August 12-16; Outer Banks, NC. [Raleigh, NC]: [North Carolina State University, College of Forest Resources, Departments of Forestry and Wood and Paper Science]: 196-203.

Arola, Rodger A.; Sturos, Joseph B.; Radcliffe, Robert C. 1991b. **U.S. chunkwood machines**. In: Arola, Rodger A., comp. Chunkwood: production, characterization, and utilization. Gen. Tech. Rep. NC-145. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 45-58. (Also in: 1988. U.S. chunkwood machines. In: Production, storage and utilization of wood fuels: Proceedings of IEA/BE conference task 3/activity 6 and 7; 1988 December 6-7; Uppsala, SE. Res. Notes 133/1988. Garpenberg, SE: Swedish University of Agricultural Sciences, Department of Operational Efficiency; 1: 1-20.)

Arola, Rodger A.; Hodek, Ralph J.; Bowman, John K.; Schulze, Gary B. 1991a. **Forest roads built with chunkwood**. In: Arola, Rodger A., comp. Chunkwood: production, characterization, and utilization. Gen. Tech. Rep. NC-145. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 29-44. (Also in: 1988. Forest roads built with chunkwood. In: Production, storage and utilization of wood fuels: Proceedings of IEA/BE conference task 3/activity 6 and 7; 1988 December 6-7; Uppsala, SE. Res. Notes 133/1988. Garpenberg, SE: Swedish University of Agricultural Sciences, Department of Operational Efficiency: 1: 128-149.)

Ashmore, Colin; Sirois, Donald L. 1987. **Influences of the central tire inflation system on log truck performance and road surfaces**. In: 1987 Summer meeting of the American Society of Agricultural Engineers; 1987 June 28-July 1; Baltimore, MD. Pap. 87-1057. St. Joseph, MI: American Society of Agricultural Engineers. 27 p.

Gililland, Ed; Ryburn, William. [1987]. **Reduced tire pressure on Forest Service roads through central tire inflation systems**. In: Tufts, Robert, ed. Improving productivity through forest engineering: Council on Forest Engineering 9th annual meeting; 1986 September 29-October 2; Mobile, AL. [Auburn, AL]: [Auburn University, School of Forestry]: 39-42.

Hodges, Henry C.; Ashmore, Colin; Smith, Eugene; Gililland, Edward; Espinosa, Eileen. 1987. **Nevada Automotive Test Center final report—central tire inflation**. Rep. 53-9JA9-6-SD647. San Dimas, CA: U.S. Department of Agriculture, Forest Service, Technology and Development Center. 142 p.

Taylor, Deborah J. 1987. **National central tire inflation program—Boise National Forest field operational tests**. Proj. Rep. 8771 1201. San Dimas, CA: U.S. Department of Agriculture, Forest Service, Technology and Development Center. 42 p.

Taylor, Deborah J. 1988. **National central tire inflation program—Olympic National Forest field operational tests**. Proj. Rep. 8871 1201. San Dimas, CA: U.S. Department of Agriculture, Forest Service, Technology and Development Center. 34 p.

Zealley, Harold E. 1990. **Operation Bigfoot: the development and application of variable tire pressure/central tire inflation technology for the National Forests of the United States**. In: Managing forestry operations in a changing environment: 1990 Proceedings of the 13th annual meeting of the Council on Forest Engineering; 1990 August 12-16; Outer Banks, NC. [Raleigh, NC]: [North Carolina State University, College of Forest Resources, Departments of Forestry and Wood and Paper Science]: 147-153.

APPENDIX

DATA ACQUISITION SYSTEM

The data acquisition system used in this study is self-contained, battery-operated, portable, and programmable. Based upon a high-speed, eight-bit microprocessor and an industrial standard bus (STD), the system is very flexible. It can be configured for a wide variety of data collection and computational tasks. This particular bus was selected because the small boards can tolerate high vibration levels, a large selection of industrial-quality STD bus boards are available for special applications from more than 100 manufacturers, and custom boards can be easily designed and constructed.

Hardware

The built-in data channels include up to 16 analog inputs (with 12-bit converters), a 16-bit digital counter, and a clock/calendar. Two timers are available; one is dedicated to determine the data sampling times. The clock/calendar is used to automatically include the date and time in the header for each data set. It can also be used to begin data collection at any preset time, permitting unattended operation.

As presently implemented, 64 Kbytes of memory are available for program storage with a data space of 256 Kbytes. One Kbyte contains 1,024 characters or 512 data values. The program memory is further divided into two parts. The first 32 Kbytes are read-only memory containing the language FORTH. Because read-only memory is permanent and nonvolatile, the entire language/operating system is immediately available for use when the system is turned on; no loading from a disk is required. The second 32-Kbyte section is nonvolatile read/write memory for application-specific program storage. Because it can be nonvolatile for several years (a small battery provides the backup power), programs for a specific application can be saved indefinitely and used countless times (until it is deliberately removed). The 256 Kbytes of data memory (that can hold up to 130,000 data samples) is also nonvolatile with a backup source that will maintain the memory content for more than a week.

Electrical power is provided by a built-in, 12-volt, sealed, rechargeable, lead-acid battery that will operate the system for about 5 hours. DC-to-DC converters generate the other required voltages. The 12-volt electrical system that is generally available on most vehicles can also be used to operate the computer or to recharge its battery. Extensive precautions have been taken to protect against errors or damage caused by the electrical transients that are common in vehicles.

Software

The FORTH language is the basis for the built-in, integrated operating system and application environment. FORTH is both fast and interactive, and it provides total access to all system resources. In addition to the FORTH core, many additional system-specific words (or commands) have been added to make using the system as easy and flexible as possible. These added words essentially form a custom set of commands that are designed especially for controlling the data acquisition process. The language core remains available to the user, however, providing total access to the underlying hardware and software structure if needed.

Although it is not necessary to be an expert FORTH programmer to collect data, some familiarity with the language will help the user understand the system and its operation. Writing programs or new commands, of course, will require a sufficient knowledge of FORTH.

OPERATION

Before collecting a set of data, the operator selects the data channels to be used, the order in which they will be scanned, the sampling frequency, and the duration of the data collection phase. A switch is pressed to start the process. An internal timer then generates periodic interrupts at the desired sampling frequency. Each interrupt initiates a scan of the specified data channels. The resulting data are stored in the nonvolatile, extended memory for later transfer to another system through an RS-232 serial link and subsequent storage on a floppy (or hard) disk.

Because the data collection phase is interrupt-driven, any other computational or control task can be programmed to run concurrently in the background. This background process will run between the interrupt-driven scans of the data channels.

Two transducers were used for the CTI study. A load cell installed in the trailer hitch measured the force exerted on the trailer by the truck. A magnetic pickup that generated one pulse for each revolution was placed next to the drive shaft of the truck. The pulses were used to increment a digital counter to permit the vehicle speed and the distance travelled to be determined. A sampling frequency of either 40 or 50 Hz was selected.

With two data channels and a 40-Hz sampling frequency, up to 32,640 sample sets can be collected before the data memory is full. This corresponds to an elapsed time of 13.6 minutes or a distance of nearly 12,000 feet at a vehicle speed of 10 mph. The data capacity is sufficient for nearly all envisioned applications.

Sturos, John A.; Brumm, Douglas B.; Lehto, Andrew.
1995. **Performance of a logging truck with a central tire inflation system**. Res. Pap. NC-322. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 10 p.

Describes the performance of an 11-axle logging truck with a central tire inflation system. Results included reduced damages to roads, improved ride of the truck, improved drawbar pull, and reduced rolling resistance. Road construction costs were reduced 62 percent, primarily due to using 33 percent less gravel.

KEY WORDS: Forest engineering, forest operations, forest roads, logging, economics.